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Habitat use by mountain vizcachas (*Lagidium viscacia* Molina, 1782) in the Patagonian steppe

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Abstract

The mountain vizcacha is a hystricomorph rodent of South America that inhabits rocky cliffs and outcrops in the southern Andes and the Patagonian steppe. We investigated habitat use of the mountain vizcacha in the Patagonian steppe by describing characteristics of the rocky cliffs that are associated with use by mountain vizcachas and habitat characteristics associated with their movements away from the cliffs. Steeper portions of the cliffs were more heavily used than less steep portions. Movements away from the cliffs were strongly associated with the amount of rock present. Habitat use by mountain vizcachas both on and away from the cliffs appears to be driven by predator avoidance. Mountain vizcachas can probably more easily escape terrestrial predators on a steep slope. They rarely venture away from rocks which may provide a means for escape from both aerial and terrestrial predators, even when they are away from the cliffs. There is presently very little predation on mountain vizcachas by native raptors and carnivores in this area, and humans are its major predators. The mountain vizcacha's pattern of habitat use, although it may have evolved in response to predation, now makes it very vulnerable to human predation.

Key words: *Lagidium viscacia*, habitat use, predation risk, Patagonia

Introduction

Mountain vizcachas (*Lagidium* spp., family Chinchillidae) are medium-sized hystricomorph rodents which live in rocky habitats in the southern Andes and the Patagonian steppe of South America (Redford and Eisenberg 1992). The mountain vizcachas of the northern Patagonian steppe (*Lagidium viscacia*) consume a variety of grasses, shrubs, and herbs, but select heavily for grasses (Galende et al. 1998; Puig et al. 1998). They may be observed in their rocky habitat during the day, sunning, grooming, and playing outside of their dens in rock crevices. When they are chased or frightened they run across the rocks to hide under rock piles or in crevices. They descend from the rocks to forage during the day and at night.

In the last hundred years, the steppe habitat of the mountain vizcacha in Argentine Patagonia has been greatly altered by grazing of domestic livestock and introduced wildlife. The diets of these exotic herbivores overlap greatly with that of mountain vizcachas (Galende and Grigera 1998). The effects of changes in plant structure and distribution on mountain vizcacha movements have not been studied. Movements of another rock-

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dwelling mammal, the pika (*Ochotona collaris*), have been shown to be affected by availability of food plants, but limited by proximity of those plants to rocks, due to increased predation risk away from the rocks (HOLMES 1991).

In this study we described habitat use by mountain vizcachas in the Patagonian steppe of Argentina in two dimensions, by evaluating habitat characteristics of the rocky cliffs they inhabit and also those habitat characteristics associated with their movement away from the cliffs. We hypothesized that habitat use by mountain vizcachas is constrained by distribution of plant foods and predation risk. We predicted that mountain vizcacha presence is associated with habitat characteristics related to food availability and escape and shelter from predators. Potential predators of mountain vizcachas in the study area are buzzard eagles (*Geranoaetus melanoleucos*), great horned owls (*Bubo virginianus*), barn owls (*Tyto alba*), culpeo foxes (*Pseudalopex culpaeus*), pumas (*Puma concolor*), Geoffroy's cats (*Oncifelis geoffroyi*), and minor grisons (*Galictis cuja*).

Material and methods

The study area is in southern Neuquén Province, Argentina. Vegetation is characterized as a grass-shrub steppe with an average ground cover of about 50% (LEÓN et al. 1998). There are numerous basaltic rock outcrops, many in the form of cliffs with vertical faces and flat tops. The study was conducted at four sites during the Patagonian summer, from January to March 1996.

We used fecal pellets as an indication of the past presence of mountain vizcachas at a certain place. Mountain vizcachas leave piles of feces at their sunning spots on the rocks and defecate during foraging as well. The use of fecal pellets to determine habitat use is often complicated by differences in defecating behavior among different habitat types or differential visibility of feces. In this study we did not compare different habitat types, but measured habitat characteristics at different points within a single habitat type (within the cliff or within the grass-shrub steppe away from the cliff). Sampling units away from the cliff were small enough ($2\ m^2$) to be inspected thoroughly for feces.

Use of cliffs

We walked transects along the tops of eight cliffs, measuring habitat variables at two randomly-chosen points within each 100 meters of transect. To estimate the amount of use of a point by mountain vizcachas we recorded the number of fresh piles of fecal pellets within 10 meters of the point. Habitat variables measured were the distance between rock crevices, depth and width of rock crevices (assumed to be related to shelter from predators), and height and slope of the cliff (related to escape from terrestrial predators, assuming that these predators are unable to move as rapidly up steep, high cliffs as mountain vizcachas). We performed a multiple regression of the habitat variables measured on the number of fecal piles at a point, it is likely that variables measured at points within the same cliff are spatially autocorrelated. Therefore, we determined significance levels independently of any theoretical distribution (LEGENDRE and FORTIN 1989) by bootstrapping the regression 1000 times (BRUCE et al. 1995).

In addition, for five cliffs we made mark-resight estimates of population size. We captured several mountain vizcachas from each cliff, placed colored plastic discs in both ears, and released them at the site of capture. Individuals could be identified by unique color combinations of the plastic discs. We returned to the cliffs several days later, counted marked and unmarked vizcachas, and used an unbiased Lincoln-Petersen estimator (LANCIA et al. 1994) to estimate the population size (WALKER et al. 2000). We did a least-squares regression between the average values for the habitat variables and the estimated number of individuals at each cliff. The small sample size precluded the use of multiple regression for this number of independent variables, so we did a separate regression for each variable. Measurements of the rocks (distance between crevices and width and depth of crevices) were log-transformed to normalize their distributions.

Movement away from cliffs

At ten cliffs we studied habitat characteristics associated with mountain vizcacha movements away from cliffs. We randomly chose two points within each 100 meters of the cliff. From each of these points, along a line perpendicular to the cliff, we randomly located one 2 m × 2 m quadrat within each of four strata. These strata were 0–15 m (A), 16 to 50 m (B), 51–85 m (C), and 86–120 m (D) from the top and bottom of the cliff. Within the quadrats we recorded percent cover of rocks (related to escape from predators), shrubs, grasses, forbs (positively related to forage availability), the invasive annual grass *Bromus tectorum*, bare soil, and dead vegetation (negatively related to forage availability). We did an arc-sine transformation of these percentages prior to analysis to improve normality (Sokal and Rohlf 1995). We also recorded the presence of rock, shrub or grass > 30 cm high (related to shelter from aerial predators), and of feces of mountain vizcachas in each quadrat. We did univariate tests for each variable (univariate logistic regression for continuous and chi-square tests for discrete variables) to determine which to include in a multivariate test. We did a multivariate logistic regression, including all variables with a probability of < 0.10 in the univariate tests, to evaluate which habitat variables were associated with presence of mountain vizcachas within a quadrat (Hosmer and Lemeshow 1989).

All statistical analyses were performed with the program Statistica (StatSoft 1995) except for the randomization tests which were performed with the program Resampling Stats (Simon et al. 1995).

Results

Use of cliffs

The extent to which different portions of a cliff were used by mountain vizcachas was related to the width of rock crevices and the slope of that portion of the cliff (Tab. 1). When variables with probabilities > 0.05 in the multiple regression model were excluded, the final regression resulted in coefficients of 0.10 for slope of the cliff ($p < 0.01$), 0.09 for the width of the crevice ($p = 0.01$), and –1.59 for the intercept ($p = 0.83$). The portions of the cliffs that were steeper and had wider crevices were more heavily used than portions that were less steep, with narrower crevices.

The average slope of the cliff was also the variable most strongly related to the number of individual mountain vizcachas at the five cliffs where we had population size estimates (Tab. 2). The steeper cliffs had more mountain vizcachas.

Table 1. Bootstrapped multiple regression of habitat variables of cliffs inhabited by mountain vizcachas and number of fresh piles of mountain vizcacha feces at points along cliffs. Range = range of measurements encountered.

	Range	Coefficient	p-values
Intercept		–2.23	0.89
Distance between crevices	5–226 cm	< –0.00	0.57
Width of crevices	1–40 cm	0.08	0.05
Depth of crevices	5–145 cm	< 0.00	0.46
Height of cliff	3–23 m	–0.13	0.95
Slope of cliff	22–59°	0.16	< 0.00

Table 2. Regressions of average of habitat variables measured at a cliff and number of mountain vizcachas at a cliff (S. E. = standard error of the coefficient; df = 3 for all tests).

	Coefficient	S. E.	t	p-values
Distance between crevices	0.11	± 1.05	0.10	0.93
Width of crevices	0.90	± 0.91	0.99	0.41
Depth of crevices	1.80	± 1.27	1.42	0.25
Height of cliff	0.20	± 0.11	1.80	0.17
Slope of cliff	8.92	± 2.31	3.86	0.03

Movements away from cliffs

Mountain vizcacha feces were less likely to be found as distance from the rocky cliff increased. In a logistic regression analysis (n = 228) testing the probability of encountering mountain vizcacha feces away from the cliff as compared to the probability of encountering them in stratum A (≤ 15 m from the cliff), coefficients for the strata away from the cliff were negative and increased in magnitude with distance from the cliff (stratum B = –1.67, $p < 0.00$; stratum C = –2.09, $p < 0.001$; stratum D = –2.76, $p < 0.00$). In a logistic regression without stratum A (n = 169), there was no difference in use of strata B and C ($p = 0.74$), but signs of mountain vizcachas were less likely to be encountered in D (coefficient = –0.58, $p = 0.04$). Thus, mountain vizcachas used the first 15 meters away from the cliff much more heavily than the area 15–85 meters away, and were even less likely to use areas > 85 meters away.

Because activity of mountain vizcachas was so highly concentrated in the first stratum, we removed this stratum from the remainder of the analyses to facilitate detection of differences associated with habitat characteristics away from the cliff. In the univariate analyses, presence of mountain vizcacha feces in a quadrat was positively associated with percent of rocky cover and the presence of rocks > 30 cm in the quadrat (Tab. 3 and 4). Presence of feces was negatively associated with the percent cover of bare ground, dead vegetation and *Bromus tectorum* (Tab. 3). There was no association between presence of mountain vizcacha feces and amount of vegetative cover (other than that of the invasive *Bromus tectorum*) or the presence of grasses or shrubs > 30 cm tall (Tab. 3 and 4). In the

Table 3. Univariate logistic regressions of presence of mountain vizcacha pellets and percent cover of micro-habitat variables measured in quadrats away from cliffs (Mean = mean percentage of cover within quadrats with and without mountain vizcacha feces; S. E. = standard error of the estimate; df = 167 for all tests).

	Mean without vizcacha feces (± S. E.)	Mean with vizcacha feces (± S. E.)	Estimate	S. E.	t	p-values
Bare ground	21.9 (1.8)	15.3 (2.6)	–1.31	± 0.74	–1.77	0.08
Rock	20.5 (1.9)	40.2 (3.8)	2.97	± 0.66	4.50	0.00
Dead vegetation	20.0 (1.7)	12.4 (2.1)	–1.96	± 0.87	–2.26	0.02
Shrubs	22.0 (2.1)	20.9 (2.8)	0.16	± 0.55	0.30	0.76
Grasses	9.3 (0.9)	7.7 (1.5)	–0.71	± 1.01	–0.71	0.48
Forbs	2.6 (0.5)	2.8 (0.9)	0.69	± 1.35	0.51	0.61
Bromus tectorum	6.7 (0.8)	4.2 (1.2)	–2.81	± 1.29	–2.18	0.03

Table 4. Univariate chi-square tests of association of rock, shrub, and grass > 30 cm tall with presence of mountain vizcacha feces in quadrats away from cliffs (df = 1 for each test).

	Number of Unoccupied Quadrats	Number of Occupied Quadrats	Chi-square	p-values
Tall rock	26	16	4.72	0.03
No tall rock	100	27		
Tall shrub	42	15	0.03	0.85
No tall shrub	84	42		
Tall grass	30	7	1.06	0.30
No tall grass	96	36		

Table 5. Parameter estimates and probabilities in multivariate logistic regression of presence of mountain vizcacha fecal pellets in a quadrat and micro-habitat variables with $p < 0.10$ in univariate tests (S. E. = standard error of the estimate; df = 163).

	Estimate	S. E.	t	p-values
Constant	–1.88	0.96	–1.96	0.05
Bare ground	–0.42	0.89	–0.47	0.64
Rock	2.86	0.87	3.29	< 0.00
Dead vegetation	–0.38	1.06	–0.35	0.72
Bromus tectorum	–1.77	1.44	–1.23	0.22
Presence of rock > 30 cm	–0.35	0.48	–0.73	0.47

Table 6. Two-factor ANOVA (Site, Presence of Mountain Vizcachas) with percent of rocky cover as dependent variable (MS Effect = mean square of the independent variable term; MS Error mean square of the error term).

	df Effect	MS Effect	df Error	MS Error	F	p-values
Site	3	0.05	161	0.09	0.58	0.63
Vizcachas	1	1.00	161	0.09	10.75	< 0.00
Site*Vizcacha	3	0.05	161	0.09	0.55	0.65

multivariate logistic regression analysis including those variables with a probability of < 0.10 in the univariate tests, the only variable that was significantly correlated with presence of mountain vizcachas away from the cliff was the percentage of a quadrat which was covered by rock (Tab. 5). A final logistic regression model using only the amount of rocky cover significantly predicted the presence of mountain vizcacha feces in a quadrat ($Chi^2 = 25.07$; df = 1; $p < 0.001$).

To determine if this effect of amount of rock was due to differences or correlations among the four sites within which the ten cliffs were located, we did an ANOVA with two factors, site and presence/absence of mountain vizcachas, and rocky cover as the dependent variable (Tab. 6). This analysis indicated that rocky cover did not differ by site, and that there was no interaction between site and presence/absence of mountain vizcachas. Thus, differences among sites in abundance of mountain vizcachas and/or availability of rock are not responsible for the relationship we found between the probability of presence of mountain vizcachas and amount of rocky cover.

Discussion

Presence of mountain vizcachas was associated with habitat characteristics related to escape and shelter from predators within the cliff. Mountain vizcachas can probably more rapidly escape terrestrial predators on the steeper rocky terrain which they use more heavily than less steep areas, and wide crevices in the rocks of the cliff provide refuge from predators. Away from the protection of the cliff, the ability to quickly return by running over rock appears to be more important than the availability of shelter, as the mountain vizcachas preferred rocky substrate over tall rocks and vegetation.

Mountain vizcacha presence was not related to the amount of vegetation, suggesting that access to vegetation is constrained by its proximity to rocks, as is the case for the pika (Holmes 1991). However, our inability to document any relationship between vegetation and mountain vizcacha movements could be caused by our failure to distinguish among grass species. Puig et al. (1998) suggest that as mountain vizcachas move farther from the cliff they are increasingly selective in their diet. Nevertheless, if such an association was present in our study, movements of mountain vizcachas were still limited to areas with adequate rock cover. If local food sources are reduced or depleted, as may occur with overgrazing by domestic livestock and exotic species, mountain vizcachas may be unable to extend their foraging activities beyond a safe distance from the cliff or rocky areas. This would result in reduced carrying capacities of cliffs and decreased population sizes of mountain vizcachas. Indeed, mountain vizcacha numbers have declined in our study area over recent years, both in numbers of colonies and numbers of individuals within colonies (Walker and Novaro unpubl. data).

Diets of all potential predator species have been studied within the area during the last ten years, without revealing a single case of predation on mountain vizcachas (buzzard eagles: Hiraldo et al. 1995; great horned owls: Donázar et al. 1997; barn owls: Travaini et al. 1997; grisons: Diuk-Wasser and Cassini 1998; great horned owls: Trejo and Grigera 1998; culpeo foxes, pumas, Geoffroy's cat: Novaro et al. 2000). A study done in the area 40 years ago reported consumption of mountain vizcachas by culpeo foxes (Crespo and DeCarlo 1963). The European hare (*Lepus europeaus*) was introduced to Argentina in 1896 (Grigera and Rapoport 1983) and spread into this area of Patagonia a few decades later. It is currently the main component of the diet of most predators, and may have replaced the similarly-sized mountain vizcacha as a prey item in the area (Novaro et al. 2000). Predation on mountain vizcachas by terrestrial predators at a site without hares in the puna of northern Argentina is very heavy (Perovic et al., unpubl. data). Predators at this site include the culpeo fox and puma, as in the Patagonian steppe, but also the Andean cat (*Oreailurus jacobita*), which may be specialized for predation on mountain vizcachas.

Although the mountain vizcacha in this region of the Patagonian steppe is not presently a major component of the carnivores' diets, it probably had a long evolutionary history during which it was. In the absence of heavy predation pressure today its behaviour may continue to be driven by predator avoidance. Very low levels of predation may still be a major threat to already reduced populations of mountain vizcachas, however. As local populations may be very small and dispersal corridors interrupted by human activities, even occasional loss of individuals to predation could contribute to local extinctions due to demographic stochasticity.

Currently, the primary predators of mountain vizcachas in our study area are humans. Mountain vizcachas are frequently hunted by local people for food (Funes and Novaro 1999) and for sport. The behaviors this rock-dwelling species has evolved to avoid predation are not effective for the evasion of human predation. A mountain vizcacha perched on a steep rocky cliff may be inaccessible to terrestrial predators and may see the approach of both aerial and terrestrial predators from far away, but is an easy target for a rifle. Isolated local populations are easily hunted to extinction by humans (Walker and Novaro, unpubl. data). Thus the mountain vizcachas of the Patagonian steppe exhibit a pattern of habitat use which probably helped them avoid predation in the past, but which paradoxically exposes them to greater risk of predation by humans today.

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Zusammenfassung

Habitatnutzung durch Bergviscachas (Lagidium viscacia Molina, 1782) in der patagonischen Steppe

Das Bergviscacha ist ein hystricomorphes Nagetier Südamerikas, das felsige Höhenzüge und Felsengelände der südlichen Anden und der patagonischen Steppe bewohnt. Untersucht wird die Lebensraumnutzung des Bergviscachas in der patagonischen Steppe, indem Charakteristika der felsigen Höhenzüge beschrieben werden, die mit der Nutzung durch das Bergviscacha zusammenhängen, sowie Charakteristika des Habitats, die mit Ortsveränderungen außerhalb der Höhenzüge zusammenhängen. Steilere Felsabschnitte wurden intensiver genutzt als weniger steile. Die Ortsveränderungen außerhalb der Höhenzüge hingen eng mit der Größe vorhandener Felsmassen zusammen. Die Habitatnutzung der Bergviscachas scheint inner- wie außerhalb der Höhenzüge durch die Vermeidung von Räubern beeinflusst.

Bergviscachas können Landraubtieren wahrscheinlich auf einem steilen Abhang leichter entkommen. Sie wagen sich selten von Felsen fort, die auch außerhalb der Höhenzüge Fluchtmöglichkeiten sowohl vor Luft- wie vor Landraubtieren bieten. Es gibt zur Zeit in diesem Gebiet sehr wenig Prädation auf Bergviscachas durch einheimische Greifvögel und Fleischfresser, wodurch der Mensch zum wichtigsten Räuber wurde. Wenngleich das Muster der Habitatnutzung des Bergviscachas als Reaktion auf Verfolgung durch tierische Räuber entstanden sein mag, wird es hingegen sehr anfällig für Verfolgung durch den Menschen.

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